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EXERCISE AND OVER-EXERCISE.

BY

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There is generally a great deal of truth in old proverbs because they represent the essence of much observation which has been condensed together and cleared of all unnecessary surroundings. The proverb that "it is better to wear out than to rust out" is no exception to the rule, and an article in constant use is very likely to stand longer than one totally disused and exposed to rust, to say nothing of the advantages obtained by using it instead of allowing it to lie idle. But over-use will wear out things before their time, and every mother knows that a boy's clothes do not last anything like so long when the boy is wearing them as if they were put up with camphor in a wardrobe. Use is good but over-use is bad, and what is true of implements and clothes is true also of the human body. Exercise of all the various parts tends to keep them in regular working order and prevents them from undergoing premature decay, but over-exertion, on the other hand, tends to break them down before their time. Now we may have exertion of all the different parts of the body—of the brain, of the limbs, of the digestive organs—and although it is necessary for the perfect life of man that these all should work, they cannot all work at their full power at the same time. The most accomplished author or the greatest mathematician would not choose the hour immediately after a heavy dinner to write a book or solve a problem, and a man I knew used to sit down in an easy chair every Sunday afternoon, and announce to his family that he was going to meditate on the sermon he had heard shortly before, but in a very short time the result of his meditations was announced by a series of loud snores. Most of you have heard of Mark Twain's horse, which looked as though it wanted to lean up against a post to think, and I daresay many of you

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* The Inaugural Address, York Medical Society, October 12, 1898. Reprinted from the *Medical Chronicle.*

FIG. 1.

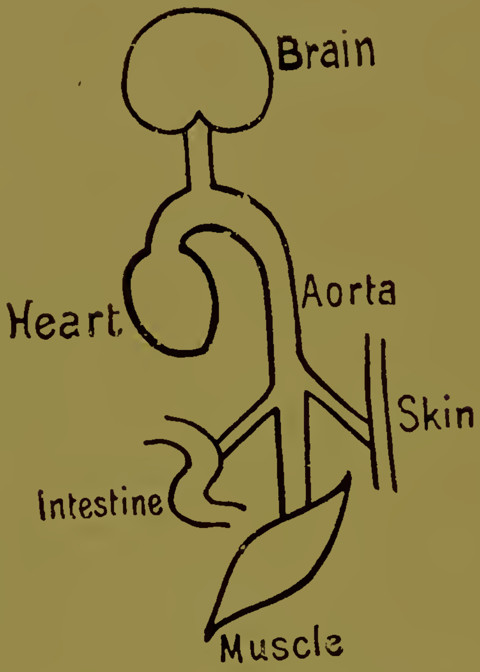
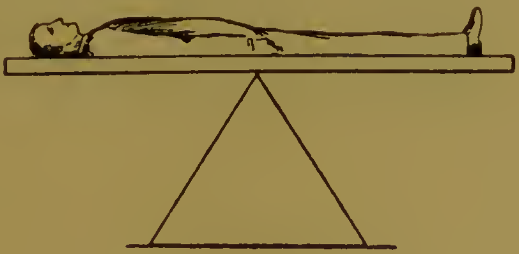


Diagram showing the four great areas for the distribution of blood in the body, viz., the muscles, the brain, the intestine and the skin.

have noticed that when people are asked a question while walking, they not infrequently stop to think. We see, then, that digestion and bodily exercise are both to a certain extent incompatible with severe mental exertion. Bodily exercise and digestion are also to a great extent incompatible with one another, and people who begin to do active work immediately after a full meal are apt to suffer from indigestion. This is so generally recognised that if we go about midday through the street of a town which is being repaved, or through a harvest field which is being reaped, we find the workmen and reapers take a much longer break than is necessary merely to consume their food, and they rest for a long while afterwards, so as to allow time for digestion. One of the chief reasons why the brain, legs and arms, and the digestive organs cannot all work at the same time is that they all not only require blood to do their work, but the more work they do the more blood they need, while there is not enough blood in the body to supply all of them fully at the same time. In some towns where the water supply is rather short we find turncocks who go about turning the water supply on to one district while they turn it off from another; and in the body we have a set of nerves—the vaso-motor nerves—which have a similar duty, and turn off the supply of blood from one part while they turn it on to another. Thus after dinner they turn the blood on to the digestive canal, and turn it off from the legs, arms, and brain. When a man stops to think they turn it on to his brain and off from his legs and arms. This has been shown in a very neat way indeed by my friend Professor A. Mosso, of Turin, who had a long table so delicately balanced on its axis that it would turn one way or another with a very slight weight. Upon this he laid a man so that his head and legs were equally balanced, and the table remained exactly level. On telling the man to think vigorously, the blood left his legs and went to his head, with the result that the head went down and the legs went up. He showed the same thing in another way; he put the arm into a vessel full of water and connected this with an index (Fig. 3). As soon as the man who was being experimented upon began to do a mental calculation, the blood left the arm to go to the brain, and so the index fell (Fig. 4).

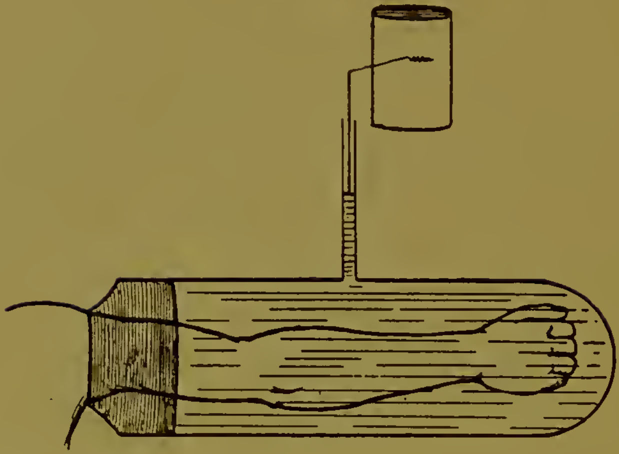
FIG. 2.



Mosso's Table Balance.

But it is not only the blood-vessels that are altered by exertion, the heart itself and the breathing apparatus also take part in the change. The breathing becomes quicker and the action of the heart both quicker and stronger. The various

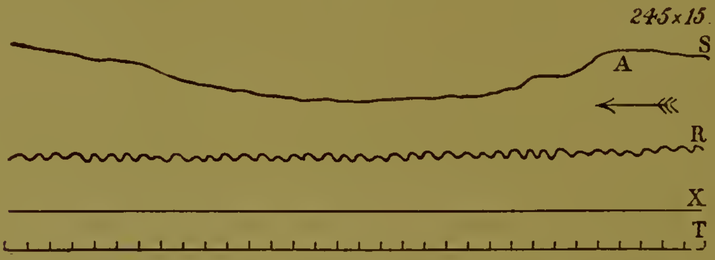
FIG. 3.



Mosso's Plethysmograph. The index is represented writing on a revolving cylinder.

organs of the body are so closely connected together that one affects the other in a way we would hardly dream of until we actually make the observation. If you wish to test this for yourself, get a friend to bend his forefinger and keep it bent

FIG. 4.



To show the contraction of the vessels produced during the process of multiplying 245 by 15. S, Volume of left arm. A, marks the point at which the calculation was commenced; after this point the pressure falls. R, Respiratory movement of chest. X, Abscissa. T, Time line; every upright marks an interval of five seconds.

while you try to straighten it. While you use one hand to do this, put your other upon his forearm and you will feel the muscles become hard. Then put your hand half way between his elbow and shoulder, and you will probably feel the same thing, and then putting your hand upon his breast you may find that the muscles there are also taking part, so that in the very simple act of bending the forefinger you get the muscles of the hand, arm, and upper part of the body all thrown into action at once. Nor is this all, for if you count the pulse before and after, you will find that it has become more rapid after the exertion, and probably respiration will become quickened as well.

We thus see that the very simplest movement affects the heart and lungs as well as the muscles. Now it is just possible that there are some here who may not know exactly what muscles are. I should not dare to assume this if it were not that in one of his novels Sir Walter Scott makes the mistake of saying that one of his characters had not an ounce of superfluous flesh on his limbs, they were all muscle. Now flesh and muscle are identical, and the red flesh which you see in a butcher's shop is simply the muscles by which sheep or oxen move their limbs. In shortening, so as to pull upon the bones and move the limbs, a certain amount of waste takes place in the muscle, a certain amount of material is used up, and a certain amount of what we may call muscular ash is formed. Now this muscular ash first produces fatigue and weakness in the muscle, and would ultimately paralyse it altogether, just as the ash of the fire will finally lessen the flame, and if not removed will finally put it out. In order to supply the muscle with fresh material and remove this waste, more blood flows into it when it has been set in action. This increased circulation not only tends to prevent exhaustion of the muscle, but ultimately causes it to become larger and stronger; and everybody knows that if one boy chooses the trade of a blacksmith, while his brother, exactly the same size and strength as himself, chooses to become a clerk, the blacksmith's arm would become much larger and stronger in six months than that of the clerk. But we have already seen by the simple experiment of bending the finger against resistance that the heart and lungs participate even in such slight movements, and with increased exercise to the muscles the heart and breathing apparatus also get more exercise, and they tend to become larger and stronger than before. Nor is this all. The increased waste and the increased circulation lead to greater excretion from the kidneys and skin, and at the same time they produce a greater appetite and a more active and healthy condition of the digestive canal. Every vital process is carried on more vigorously, and the individual feels brighter, happier, better able for work, and is not only capable of enduring greater exertion, but is better fitted to resist attacks of disease. The uses of exercise are so obvious, that we often hear people say in regard to their friends with ailing health, that if they would only take more exercise they would become perfectly well; but there are great differences in the effects of exercise, according as it is of a suitable character and taken at suitable times or not.

We have already seen that severe bodily exercise should not be taken immediately after meals, although a quiet stroll may not interfere with digestion. A quiet stroll, or as people often call it a "constitutional," has less power than actual exercise for harm, but it has also less power for good, and we shall be disappointed if we expect from it the increased appetite and the better digestion which would follow such exercise as a game of cricket, golf or lawn tennis. There are two reasons for this. One is that in the constitutional the movements of the limbs are less active, the heart and lungs are not stimulated, and moreover, fewer muscles are brought into play than in the games which I have just mentioned, where the arms and trunk are actively employed and not the legs only, as in a constitutional. Another reason is that a constitutional does not help to increase the excretion of bile. Bile is formed in the liver at very low pressure, and will hardly run out unless the liver be to a certain extent squeezed between the diaphragm and abdominal muscles. Now this squeezing does not occur in a constitutional walk, but it does take place when the abdominal muscles are tightened at the same time that a deep breath is taken. By putting the hand on the abdomen you will find that in quiet walking the muscles tighten but very slightly, but in running or walking up a hill they tighten very much more, and a quarter of an hour's walk up a steep hill will do a man more good than a couple of hours' walk on level ground. Where people have not the time or opportunity of walking uphill they may help the liver by one of the movements which are generally taught at the commencement of drill, namely, trying to touch their toes with their fingers while they keep their knees straight.

By doing this a few times morning and night they may keep their livers in order, and sometimes avoid the depression of spirits, melancholy and discomfort, which are associated with hepatic disorder. At the same time pressure upon the intestines, either by the exercise of cricket or tennis, or such movement of drill as I have mentioned, tends to make them act and lessens the necessity for continuous dinner pills. But in some people the muscles of the abdomen, through long disuse, have become so feeble that they have little power either to squeeze the liver or intestines. What is to be done in such cases? The best thing is either to have them subjected to a course of massage, or, if this is not available, to use such exercises as will increase them, beginning with very gentle movements. One exercise is to lay hold of the back of a chair so as to prevent oneself from falling, and then to raise first one foot and then the other as high as possible in front. In his book on *Training*, Sandow describes another exercise, which is to lie on the back in bed or on a sofa and raise both legs with the knees straight as high as possible into the air. Much the same result is obtained in a more graceful way by letting the legs remain on the bed and raising the body into a sitting position, or even bringing it further forward. For the development of the chest there is perhaps no exercise better than that which Nature has pointed out as a relief to fatigue, namely, yawning, for in this action the chest is expanded to the utmost both by the ordinary inspiratory muscles and by the accessory muscles connected with the arms. In cases where chest expansion is deficient, either from arrested growth in children or from disease of the respiratory passages or pleura, the movements of yawning repeated several times tend to increase the chest capacity. But this should be done where the air is clean and fresh and free from germs, because more air is drawn in and it is drawn more deeply into the chest than in ordinary breathing, so there is a greater chance of microbes getting deeper into the lungs, if any should happen to be present in the air. Movements like those of yawning, though perhaps less extensive, occur when a skipping rope is used backwards, and I do not think there is any better exercise for children with imperfect expansion of the chest than skipping backwards. The movement of skipping forwards is not nearly so good, as the inspiratory muscles are not used to the same extent, and the action tends rather to contract the chest than to expand it. This also is the case with bicycle riding, which tends to narrow the chest and cause a more or less permanent stoop. Now cycling has become such a very general amusement that we must consider its effects upon the body, and compare them with those of other physical exercises, and especially with lawn tennis. Lawn tennis as an amusement seems to be less general than it was some years ago, and on asking people at garden parties whether they will play lawn tennis, many of them say they have come by a cycle and have some distance to cycle back, so they would prefer to play something easier, such as croquet. Now of late years it is a matter of general remark how tall and strong the girls are who are to be seen in ball rooms as compared with what they used to be twenty years ago. It is a curious coincidence that this increased growth seems to have occurred along with the introduction of lawn tennis—possibly it may be due to it.

We have already seen that increased exercise tends to make the muscles grow larger, and that at the same time the heart and lungs are stimulated. Now stimulation of the circulation and respiration increases the nutrition throughout the whole body, and when not overdone will tend to cause increased growth. The effect of over-exertion and over-stimulation we shall have to consider later on. It is very interesting and instructive to compare the sketches in *Punch* of girls playing croquet by Leech, and a game of lawn tennis by Du Maurier. In Leech's sketches we see that the girls are much smaller, the exertion they make is slight, and their movements are not only stiff but they exercise only a few muscles; while Du Maurier's girls are tall, strong, lithe and graceful, and in striking the ball put every muscle in their body into active exercise. Now in lawn tennis or polo there is more general movement of the whole body than in croquet, cricket or golf, and it is just possible that the increased growth in recent years of girls, as compared with their brothers, may be due to more general exercise of the muscles in lawn tennis by them as compared with the more restricted action in playing cricket. But in all the games that I have mentioned there is one essential, viz., intermittent action* (*vide* Figs. 5, 6, 7 and 8).

Exercise which puts in action every muscle of the body, but does not put any one into action for too great length of time at once or in too violent a manner, is exceedingly beneficial. It causes increase of strength and endurance in the muscles themselves, it augments the respiratory power, it makes the heart stronger and the circulation more active, and indirectly increases the power of digestion and the activity of the mind. It thus causes a sensation of well-being, bodily and mental, and enables the individual to resist all the various destructive agencies, microbic and climatic, which tend to produce disease, and so it tends to preserve health and prolong life.

Such are the effects of exertion, but very different indeed are the results of over-exertion. When muscles are over-exerted and kept in action too continuously we find that they grow smaller instead of larger, they become liable to spasm and pain, so that in certain trades where the workmen are over-strained we get paralysis of those muscles upon which the greatest demands are made. Over-exertion also strains and weakens the heart, lessens the mental power, destroys the appetite and renders the individual more ready to succumb to the attacks of disease and to die before his time. Thus the Greek who brought the tidings of the battle of Marathon to Athens, notwithstanding the health and strength which enabled him to perform such a feat, fell dead on accomplishing it, and young oarsmen have threatenings of a similar fate after a boat-race, although, fortunately, very few of them actually succumb. Every one knows that while moderate exercise tends to produce appetite, yet long and exhausting exertion tends to destroy the appetite, and even to produce actual sickness, as one finds in mountain climbing. Nor would any one expect an oarsman

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* The longer intervals between the active movements in driving a ball in golf make this game especially suitable for those to whom the greater strain or shorter intermissions render lawn tennis, polo or cricket unsuitable. It is thus particularly useful to men who are prevented by their occupations from keeping themselves in continuous training, or for those whose advancing years render the limbs less supple and the arteries more rigid.

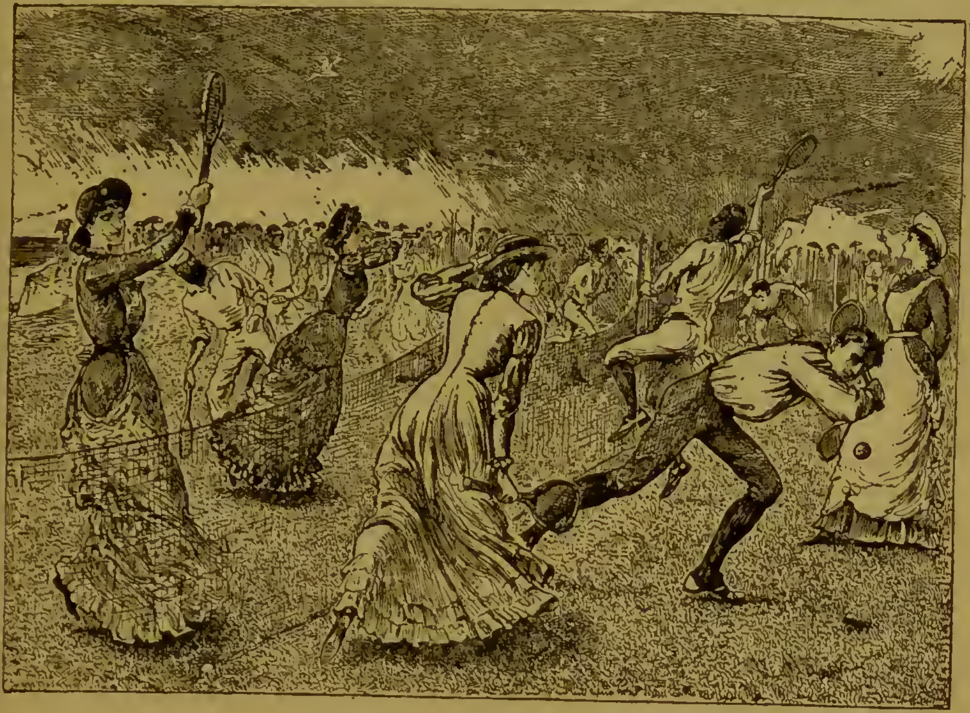
Fig. 5.

A constitutional walk. "An agreeable duty" (after Leech).—*Punch*, March, 1848, vol. xiv, p. 124. (By the kind permission of the proprietors of *Punch*.)

Fig. 6.

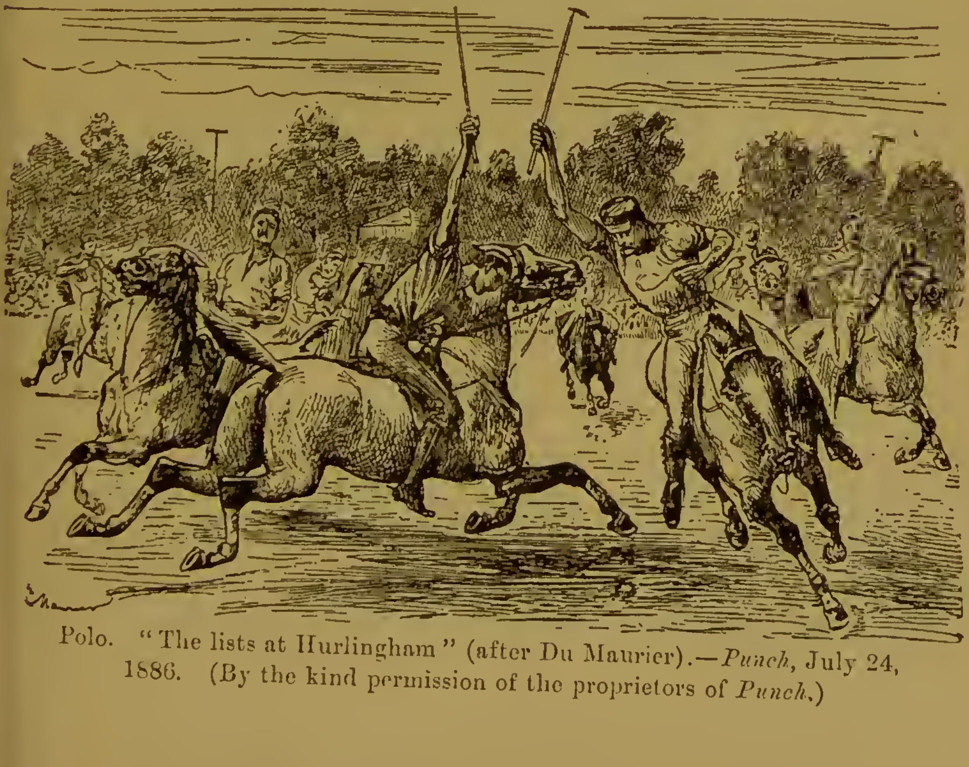
Croquet. "A nice game for two or more" (after Leech).—*Punch*, Aug. 17, 1861. (By the kind permission of the proprietors of *Punch*.)

Fig. 7.



Lawn Tennis. "A modern tournament" (after Du Maurier).—*Punch*, Sept. 3, 1881. (By the kind permission of the proprietors of *Punch*.)

Fig. 8.

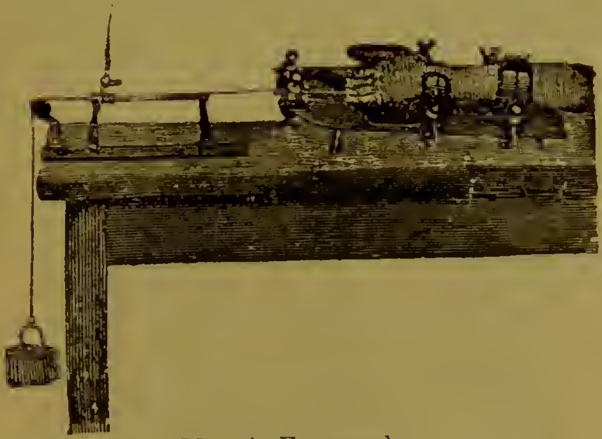


Polo. "The lists at Hurlingham" (after Du Maurier).—*Punch*, July 24, 1886. (By the kind permission of the proprietors of *Punch*.)

after a boat-race or an athlete after running a mile or exerting himself in throwing the hammer or putting the stone, to solve a mathematical problem or do a Greek translation with the same facility that he might possibly be able to show at other times.

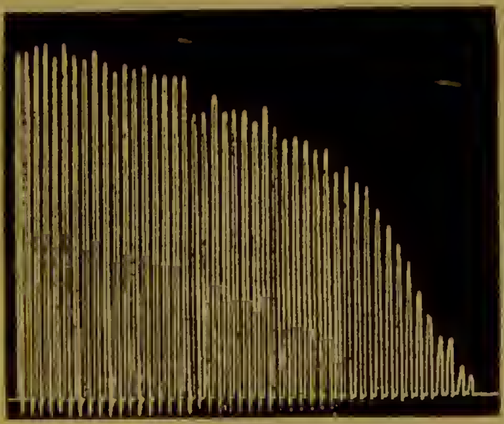
Now what is the difference between exercise and over-exercise? This question can only be answered in general terms for the simple reason that what is exercise for one man is over-exercise for another, or may even be over-exercise for the same man under different conditions. Nay more, what is sufficient exercise for the muscles may be over-exercise for the heart, and one of the risks which schoolboys sometimes run is that their athletic power may be judged by their masters or schoolfellows according to their apparent size and strength, and not according to the strength of their heart. To answer the question how much exercise a boy or a man shall take is like saying how much food he shall take. We can lay down general rules, but we cannot be sure that these will apply rightly at all times. But just as appetite regulates the amount of food that a person ought to take, so the amount of exercise is regulated by the sensations of fatigue which show that exercise is becoming too much for the muscles, or by pain in the side which shows that the heart is becoming over-strained. Now sensations of fatigue, like all other sensations, are perceived by the brain, but the condition which gives rise to these sensations is present in the muscles. The energy which enables an express train to rush along from York to London at the rate of fifty miles an hour is supplied by the combustion of coal in the furnace, and the energy which enables our muscles to contract is supplied by the combustion of certain substances in the muscle itself. In both cases the combustion leaves an ash behind which, if not removed, would in the locomotive choke the furnace and put out the fires, and in the muscle first weakens and then abolishes its power of contraction. This effect of the accumulation of waste in the muscles has been beautifully shown by my friends Professor Kronecker of Berlin and Professor Mosso of Turin. I take from Professor Mosso's work on *Fatigue* a tracing which I will show in the lantern. This was made by putting the middle finger into a loop at one end of a string, the other end of which passed over a pulley and was attached to a weight (Fig. 9). In the middle of the string a small point was fixed which worked upon a revolving cylinder

FIG. 9.



Mosso's Ergograph.

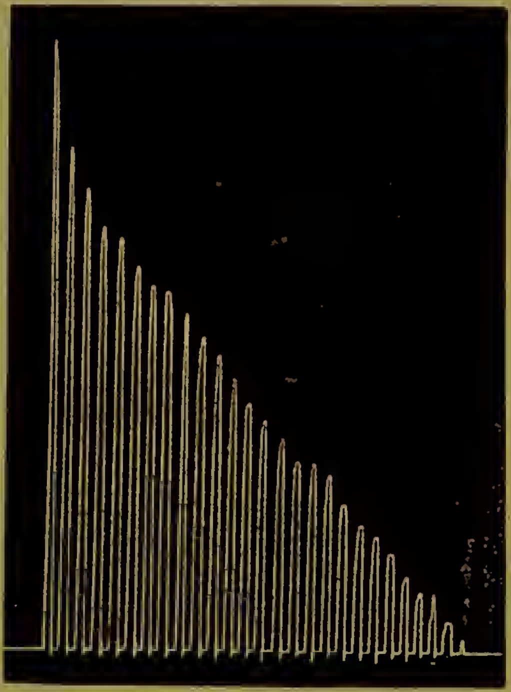
FIG. 10.



After Mosso. Exhaustion curve of finger in healthy man from voluntary movement.

covered with soot, so that each mark of the tracer could be distinctly seen. The middle finger was then contracted so as to raise the weight at intervals of two seconds. The amount of contraction is shown by the height of the up stroke, and you will see that as the exercise went on the contraction became shorter and shorter till at last exhaustion became complete and the finger ceased to move. I have already said that fatigue is a complex thing, and is partly due to the state of the muscle which causes it and partly to the state of the brain which perceives it. To show how much is due to the muscle, Mosso caused the finger to contract by stimulating the finger directly by means of electricity, and I now show you a tracing obtained

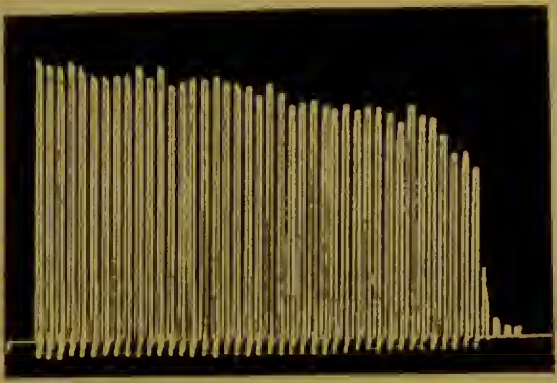
FIG. 11.



After Mosso. Exhaustion curve of finger in healthy man where the muscles are caused to contract by electrical stimulation.

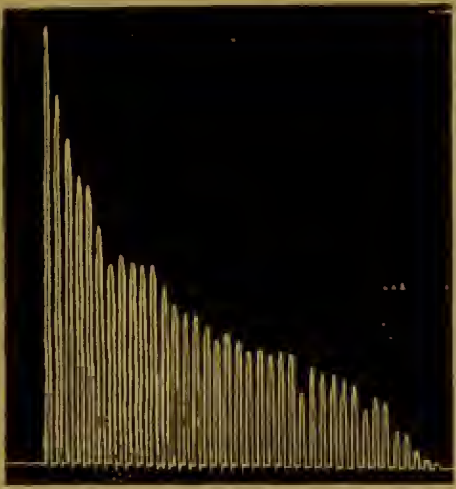
in this way (Fig. 11). You will see that it corresponds somewhat but not exactly to the first tracing, in which the fall was not a steady one, and was slow until about the end of the exercise. This difference you may fairly attribute to the action of the brain, which made the individual use his will more when he began to feel the muscles failing. But there is an enormous difference between different men, as is shown in the next two tracings, in one of which the finger has continued to contract with very little diminution up to the point of complete failure of the muscle (Fig. 12), while in the other (Fig. 13) the fall of the curve due to fatigue is very rapid.

FIG. 12.



After Mosso. Tracing from Dr. Patrizi, showing long-continued movement and abrupt failure.

FIG. 13.

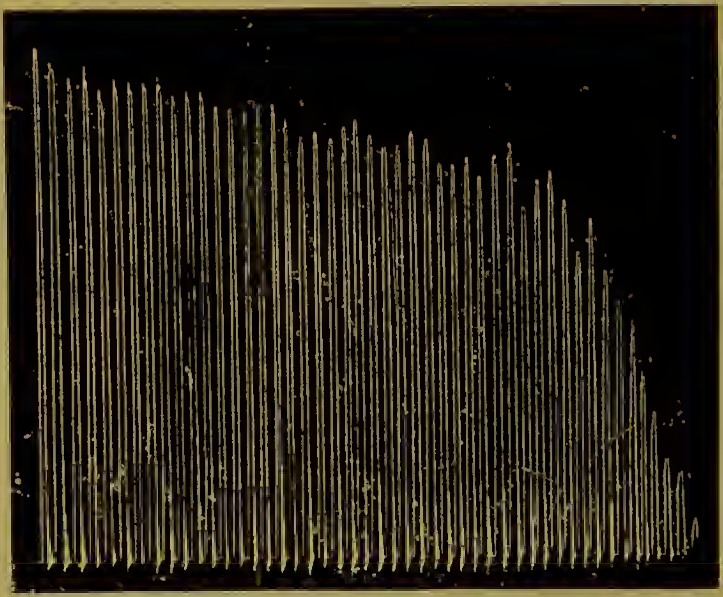


After Mosso. Tracing from Dr. Maggiora, showing rapid but gradual failure from fatigue.

Mental exertion, especially anxiety, tends to make the muscles more easily fatigued.

Now why is it that the muscles become so exhausted by exercise, and yet men are able to go on doing severe work for hours and hours together? The reason is that during contraction the blood-vessels of the muscle dilate and allow the blood to run into it, bringing new material and helping to carry away the products of waste. But the very contraction of the muscle itself tends to squeeze the blood-vessels and prevent the blood flowing through it. Consequently the greatest flow usually occurs after the muscle has ceased to contract. It is, however, evident that if a muscle be kept contracting too continuously, or if its contractions come too closely together, it will not receive as much blood as it ought, its products of waste will tend to accumulate, and it will consequently become soon exhausted. The most useful exercise is the one which puts many muscles into action by alternate exercise and rest, so that while one is contracting the others are relaxing. On the other hand a continuous strain upon one set of muscles is not only painful and exhausting, but injurious. Every one knows how much easier it is to walk than to stand still, and if we are obliged to remain in one place we involuntarily throw our weight first on one leg and then on the other, so that we get the muscles of each acting alternately. It is this continued strain, however, that makes it so hard for people who are obliged to stand still

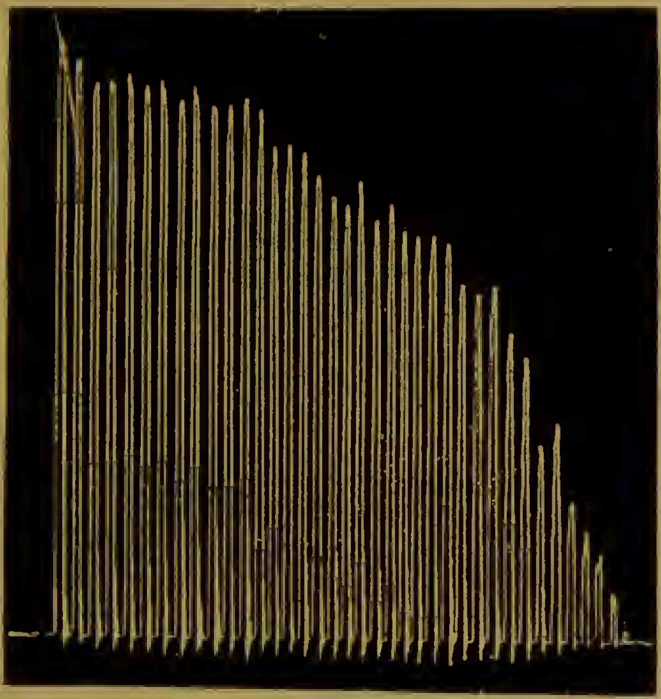
Fig. 14.



After Mosso. Normal tracing from Dr. Maggiora.

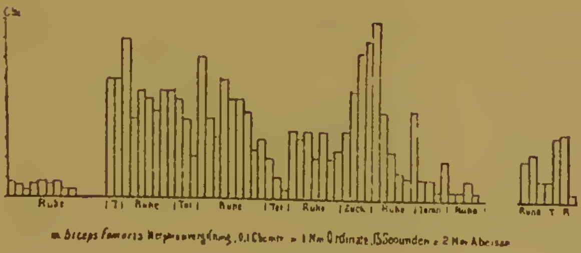
such as teachers, shop-men and shop-girls, who are upon their legs a great part of the day and are unable to walk more than two or three paces at a time, and yet cannot sit down because they have to make slight movements from place to place. To meet this a teacher's rest has been made, consisting of a small sloping board attached to an upright support, which is fixed in

FIG. 15.



After Mosso. Tracing from Dr. Maggiora, when fatigued by giving a lecture.

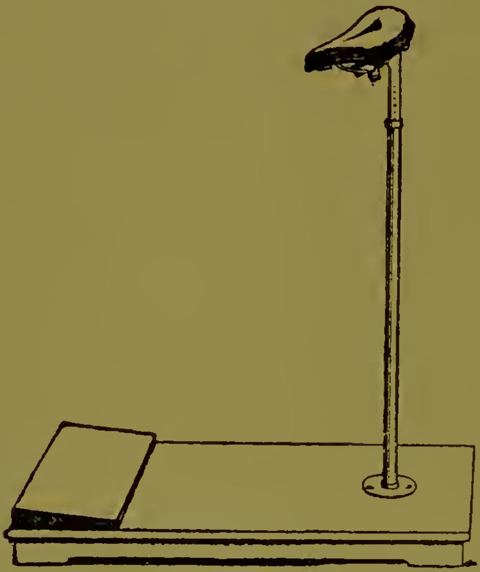
FIG. 16.



After Ludwig and Sadler. The marks along the base lines indicate seconds the height above the base line indicates the amount of blood flowing from the veins of the biceps of a dog during tetanus (T or tet), during rest (Ruhe), or during simple contraction (Zuck).

a piece of board about 3 feet long and 2 feet broad. Against this the teacher rests his weight, keeping the whole thing steady. I have had this rest, which does not take the weight of the body off the legs, modified by substituting a bicycle saddle for the sloping board. By means of this contrivance one can sit down and have the weight of the body taken off the legs, yet it hardly interferes with the movements from place to place when these are desired. By devices of this sort, which enable muscles to get alternate periods of rest and action, we may to a considerable extent prevent fatigue. But it is evident that the recuperation of a muscle will depend not only on the quantity of the blood which it receives, but also on its quality, and probably there is nothing which affects this so quickly as eating and drinking, and if we can keep the standard of blood up to a certain nutritive maximum we shall also be able to lessen fatigue. Some years ago my friend Dr. Mitchell Bruce and I were taking a walking tour in the Austrian Tyrol. By chance we found that if we ate something, however little, we

Fig. 17.



Teacher's rest. In the above model the saddle is fixed at any height by means of a pin, but in more finished instruments this should be done by a lever or screw. This model was made for me by Messrs. Hammer & Co., 370, Strand, W.C.

could walk the whole day long without getting tired. We thought we had made a grand discovery, and we intended to announce it to the world as soon as we got back. One day, however, in crossing a glacier we sat down to have our lunch, and as the guides would not allow us to start immediately after dinner we began to read our Baedeker's guide-book in order to pass the time. By chance we turned up the general directions for travellers which are placed at the beginning of the book, and as far as my experience goes usually remain unread. At any rate neither Dr. Bruce nor I had ever thought of reading them. Here, however, to our great disgust we found that the author said, "Travellers are advised to eat something every two hours in order to avoid fatigue, which might otherwise come on while crossing the ice." Since that time I have found that guides in Switzerland are well acquainted with this fact, and they generally make you sit down and eat every two hours whether you are hungry or not.

In healthy people under ordinary circumstances a longer interval is convenient and is perhaps often better, but when an individual is enfeebled by disease the same precautions against exhaustion are required in him, although he is taking little exercise, or is even lying quiet in bed, and doctors therefore direct that the patient shall be fed every two hours whether he wishes it or not, just as the guides on the Alps direct that healthy men who are undertaking extraordinary exertions shall partake of food at this interval, whether they wish it or not. More especially is feeding at intervals of two hours necessary in those who are suffering from fever, because in them the body loses as much energy in the form of heat as would have sufficed to carry it through very great exertions. But there is an old proverb that there is many a slip between the cup and the lip, and any amount of water in a cup will not quench a man's thirst unless he gets it into his mouth; and in the same way it does not matter how good the blood is in the body generally if it does not reach the muscles. Now how are we to get the blood flowing freely through the vessels in people who cannot take exercise, either because their muscles are too feeble, as in convalescence, or because their bodies are too heavy and fat, or because their hearts are too weak to stand the strain of exertion? The answer to this question is that we can do it by means of massage, which has the double effect of dilating the blood-vessels in the muscles, and thus increasing the circulation through them, and of clearing away the products of waste through the lymphatics. The power of massage to clear away waste is very extraordinary, and it has been shown by Kronecker, that if a frog's muscle be made to contract till it is completely exhausted, it will begin to act again quite briskly if simply kneaded so as to press out the muscular ash, as we may term it. The use of massage has been known to the Hindoos and to the South Sea Islanders from time immemorial, and I do not know that there is anything that strikes one as more extraordinary in the ancient Romans than the fondness that they had for baths and massage, and the regularity with which they erected baths in every town having the slightest pretensions to importance. But the muscles when put in exercise have the power of massaging themselves, because every contraction squeezes the waste products of the muscles up through the lymphatics; and a course of training exercises enormously increases muscular power and endurance. But in order that the training should have its full effect, it requires to be continuous and requires to be gentle, and I think no better example of training is to be found in the story, whether it be true or false, of Milo the famous

Fig. 18.

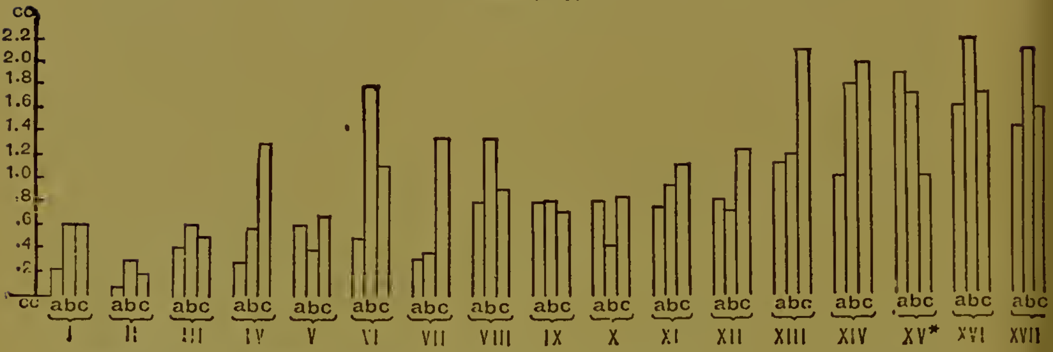
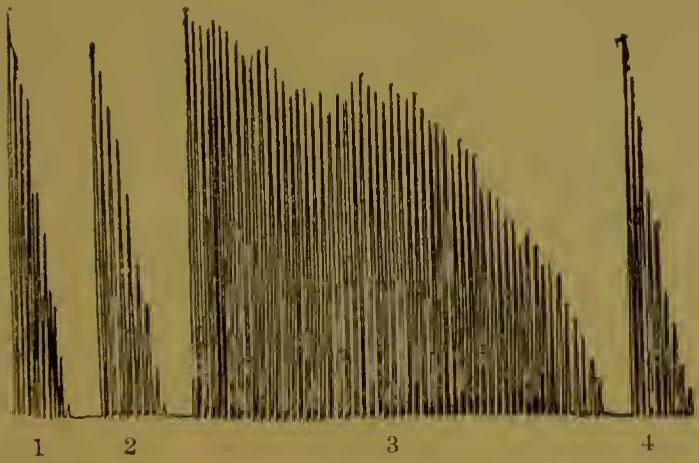


Diagram to show the effect of massage on the flow of blood through muscle; a, shows the amount of blood in cubic centimetres which flowed from a muscular vein when it was simply opened; b, during massage; c, after massage.

FIG. 19.



After Maggiora and Vinaj. Blät. f. Klin.: Hydrotherapie, 1892, p. 6. 1. The fatigue curve of the left hand raising a weight of 3 kilogrammes every two seconds. 2. The fatigue curve of the right hand. 3. The fatigue curve of the left hand after five minutes' massage. 4. That of the right hand without massage.

FIG. 20.

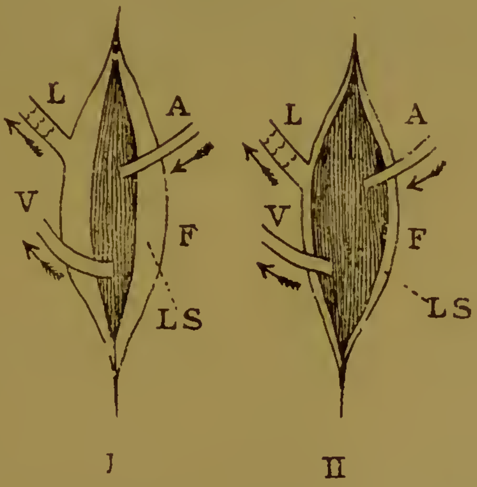
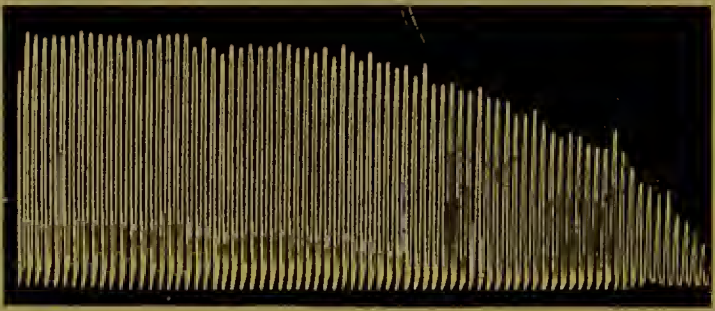


Diagram of longitudinal sections of muscles, I in relaxation and II in contraction. F is the fibrous fascia or sheath of the muscle. L S a lymph space between the muscle and the outer layer of fascia. L is a lymphatic vessel with numerous valves, by which the lymph containing waste products is removed. A is an artery by which fresh blood is brought to the muscle; and V is a vein by which blood is removed from it. Each time the muscle contracts, as in II, it lessens the size of the lymph space and drives the lymph onward through the lymphatics. Each time it relaxes it tends to create a vacuum within the fascia, and thus lymph is sucked out of the muscle into the lymph space, while fresh arterial blood rushes into the muscle.

wrestler of antiquity, who was able at last to carry a full-grown bull on his shoulders by beginning with it as a new-born calf. Day by day he carried it as day by day it grew, and as it increased in weight so did the wrestler in strength, until at last he carried a full-grown bull with the same ease as a new-born calf. I remember a friend once remarking to me that, in walking up a hill, he took the greatest possible care not to lose a single step but to walk steadily uphill, because, he said, one step downwards was like a vote in the House of Commons which counts for two, because you have one to the bad instead of one to the good. It is therefore important not to lose a step in training, but to go steadily onwards, though so gently as to prevent the necessity of stopping or going back.

Fig. 21.



After Mosso. Showing the effect of training, in increasing endurance as compared with Fig. 10, from the same person. Owing to a difference in the apparatus the height of the curves is not comparable. The amount of work done was really double that in Fig. 10.

But fatigue and over-fatigue do not act only upon the muscles, they act upon the respiration and heart. The effect of a quick run is known to us all, and so a person who is either too stout or is very bloodless will, on running upstairs, have to stand at the top unable to speak, so that in many cases time is really lost instead of saved by running up quickly instead of walking upstairs slowly. But perhaps we do not all know what the cause of this quickened breathing is. It is really due to poisonous products which are formed by muscular action. This has been shown by a very interesting experiment. If a dog is poisoned by opium so as to be quite unconscious of all that is going on, the blood from another dog may be injected into his veins, and his breathing and heart may remain quiet as before. But if another dog has his muscles put into powerful action and some of his blood is then injected into the sleeping dog, the pulse and respiration of the latter become quickened, just as if he had been taking exercise instead of lying quiet and senseless all the time.

As the muscles become trained they form these poisonous substances in less quantity, and so people who could previously hardly run at all, on account of the breathlessness it produced, may be able to take very active exercise indeed without any shortness of breath. But the shortness of breath is not all due by any means to a condition of the muscles. It is due in very great measure—in greatest measure perhaps—to alterations in the heart.

In ordinary exercise the two sides of the heart work steadily together, and the right side drives the same quantity of blood through the lungs at each beat as the left drives through the body. But when the exercise is too violent this balance is disturbed, the blood rushes more quickly through the vessels of the muscles into the veins than it can get back through the vessels of the lungs, and thus the right side of the heart becomes engorged and distended. The distension may become so great that the heart can no longer empty itself, and the man or the animal falls dead, as in the case of horses that used to be ridden hard to bring a reprieve to a condemned criminal, or a stout old gentleman who has hurried to catch a train. Even healthy hearts suffer in this way, and they may become more or less permanently damaged, for when the heart becomes much dilated the valves that ought to prevent the reflux of blood become too small for the orifices they should close, and thus we get symptoms of valvular incompetency. This condition is most likely to occur when the heart is insufficiently nourished, as in old men in whom the arteries of the heart are narrowed by atheroma, or in young girls in whom the blood is impoverished by anæmia, when every exertion may bring on dilatation of the heart. Even in healthy individuals Dr. Schott, of Nauheim, has shown that this occurs by taking a photograph with the Röntgen rays before and after exercise. Such dilatation usually causes pain and a feeling of constriction over the cardiac region, and

Fig. 22.

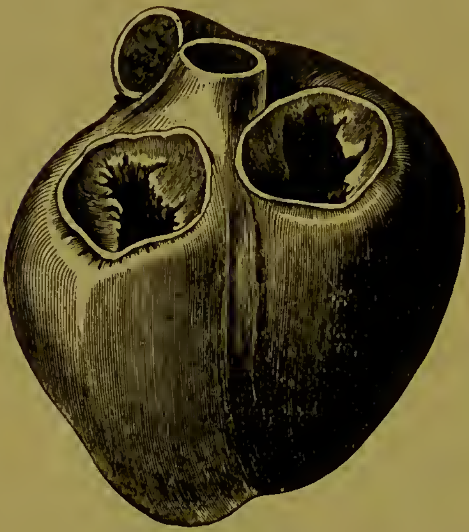


Fig. 23.

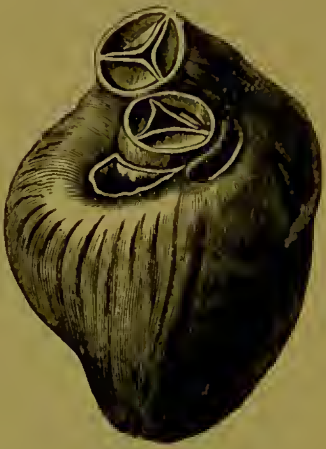


Fig. 24.

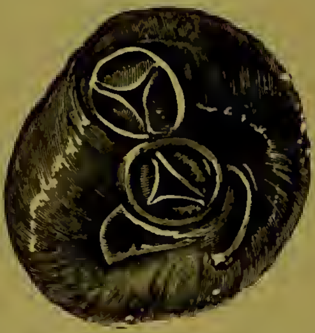


Fig. 22.—Heart fully distended, showing insufficiency of the valves to close the mitral and tricuspid orifices (seen from the back and the auricles removed, so as to display the auriculo-ventricular orifices).

Fig. 23.—Heart in full systole, showing the mitral and tricuspid orifices so diminished by the muscular contraction that the valves close them easily (seen as in Fig. 22).

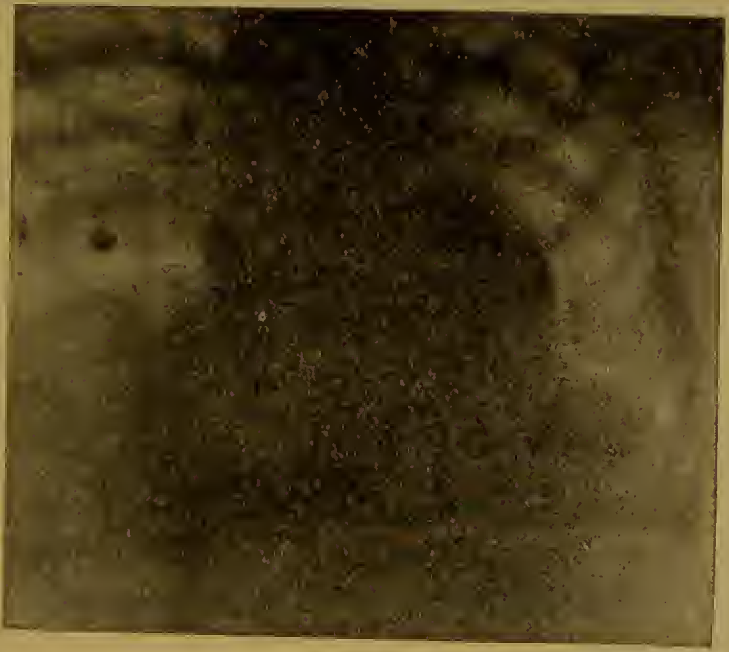
Fig. 24.—The same heart as in Fig. 23, seen from above.

the enfeebled circulation may lead to a sudden syncope. These are the conditions to which over-exertion is most likely to give rise in boys at school who go in for long paper chases, in which a great strain is made both on the strength and endurance of the

FIG. 25.

After Dr. Th. Schott. Photograph by the Röntgen rays, showing the heart in a healthy man before exertion.

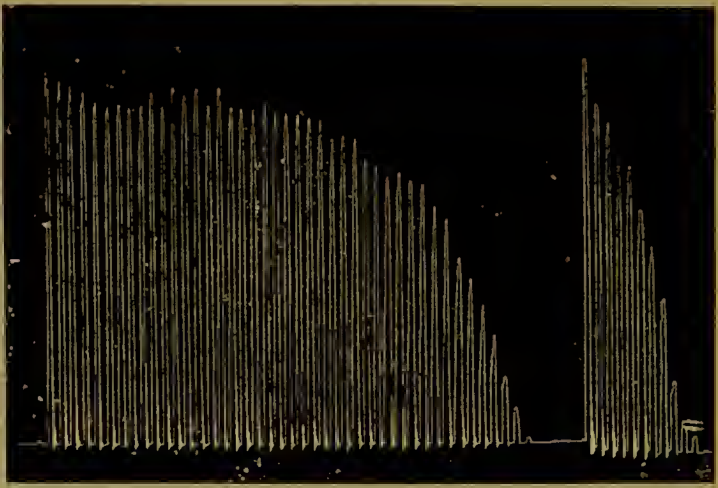
FIG. 26.



After Dr. Th. Schott. Skiagraph of the heart of the same man as Fig. 25, after violent exertion, showing temporary dilatation.

individual. A similar condition also takes place in football, in which the exertion for a time is exceedingly great, although it is not continued so long or so steadily as in the case of a paper-chase. But in growing boys both these games may lead to distinct strain of the heart, and this is all the more likely to occur if the boys are growing rapidly, for not only are the tissues as a rule softer and looser, but the boy is called upon to make exertions calculated according to the size and strength of his muscles, and not according to the strength of his heart. In all exercises attention should be paid to the condition of the heart, as excessive demands made upon its strength are most injurious in growing boys, and should be prevented, although regular exercise is most useful and beneficial.

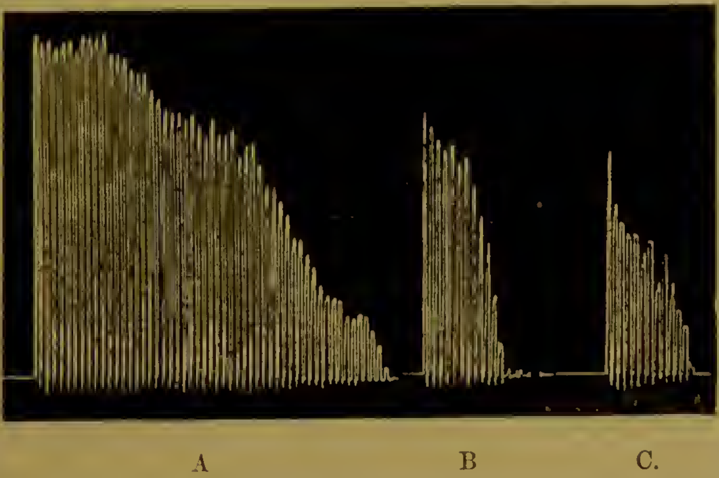
Fig. 27.



After Mosso. Voluntary contraction. A, Before conducting an examination. B, After examining nineteen candidates.

But there is another factor which must not be lost sight of in exercises for boys and young men, and that is, that mental fatigue causes bodily exhaustion. This is apparent from the slides which I now show you (Figs. 27 and 28). You will see that in these the subject of experiment has been able to contract his finger many times in succession and thus raise a considerable weight before an examination. After an examination you will see the same individual contracts his finger only a few times and is then exhausted. This fatigue affects the muscles as well as the nervous system, for in Fig. 28 the curve was obtained by

Fig. 28.



After Mosso. Exhaustion curve from electrical stimulation. A, before examination. B, Immediately after examination. C, Two hours after close of examination.

stimulating the muscles directly by electricity. It is therefore evident that if boys are hard pushed at lessons and at exercises also they are much more likely to break down than if they were pushed at either the one or the other alone. Like other muscles, the heart in adolescence is more easily strained, but is also more ready to recover itself, and, with moderate care, will recover itself completely. Thus I have had as a patient a boy who grew very quickly, and was very tall and strong for his years. At the public school where he was he was encouraged to go in for athletics according to his apparent size and strength, but one day while sitting at his desk quietly in school he suddenly fainted. On examining him I found that he had got a dilated heart, and I explained to him that if he went on with athletics it was very likely that when he was old enough to go to college his heart would not be strong enough to allow him to enter for boat races, but if he would only take care of it and go in for moderate exercise without any severe strain he would be able for anything when he grew older. He was a sensible boy, he took my advice, and its correctness was shown by the result.

In middle age the heart is less liable to strain, but as age advances, and especially if the arteries become atheromatous and the coronary vessels become narrowed, the heart not only becomes more easily affected by strain, but it has less power of recovery.

In such patients when the muscle of the heart is beginning to yield, and the cavities of the heart become dilated, recovery is slow. Now such dilatation may occur in consequence of the heart itself becoming ill-nourished and weak from several causes. The blood itself may become impoverished from imperfect food, imperfect digestion, or a constant drain such as that caused by hæmorrhoids; or while the blood is normal its supply to the wall of the heart may be diminished in consequence of atheromatous degeneration of the coronary arteries; or the strain upon the heart may be too great on account of the high blood pressure in persons with kidney disease; or dilatation may occur from over-exertion in middle-aged or elderly people just as it may in the young, or finally it may occur in consequence of valvular disease. In all cases where dilatation has occurred it is of the utmost importance to remove the causes, if possible; to correct the condition of the blood; to lessen the tension in cases of kidney disease, and to remove any cause of undue strain that may be present from the ordinary avocations of the individual, or from extra exertions which he may be likely to make in consequence of his natural temperament. Where the mischief is only slight it may be controlled to a great extent by careful training, just as in the case of a boy or youth, by constant steady exercise, avoiding with the utmost care any over-strain—*e.g.*, I am often asked by middle-aged people whether they may cycle or not, and my usual answer to those people is that they may do so under certain conditions, viz., that they shall not go too fast or too far, nor cycle uphill.

When dilatation has actually begun to interfere with the power of the patient to take ordinary exercise we must restore the heart. In many cases this can be done to a very great extent by the combined use of movements and baths, which has lately come so much into vogue under the name of the Nauheim treatment. Two or three years ago I recommended this treatment to a young officer who had strained his heart by carrying a heavy man for a wager. His ordinary medical adviser pooh-poohed my advice on the ground that the Nauheim treatment was too new and too uncertain for him to sanction its employment. Such an objection is now out of place, for the utility of this method of treatment has now become generally recognised and it is largely patronised in this country.

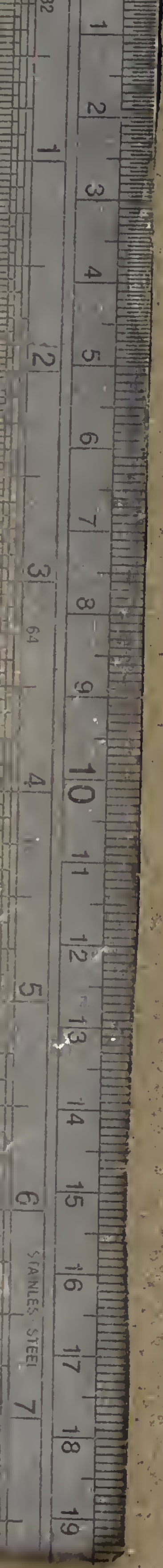
The essence of the treatment consists in the combined use of baths and movements. By the baths a stimulus is applied to the skin which acts reflexly on the heart and circulation, slowing the beats of the heart while rendering them more powerful. The movements at first are few and gentle, and their number is gradually increased, while the resistance opposed to each movement is the essential part of the treatment and is so gradually augmented that almost imperceptibly the patient is led to take a considerable amount of exercise, and that of a fairly severe nature, before the end of the course, while the increase day by day is so slight that it is almost imperceptible. The plan is now employed as an addition to the ordinary baths and waters at some of our known best health resorts, as Buxton, Harrogate, Bath, and Sidmouth, while at Llangammarch, in Wales, not only is this treatment carried on, but the place is arranged with sloping walks of gradually increasing steepness, so that the patients gradually take more and more severe walking exercise and thus continue the cure which has been begun by the resistance of movements and baths. But there are many cases where the disease of the heart is too severe to allow of treatment by baths or movements at all, where the right heart is failing, the legs are failing, fluid is collecting in the abdomen, and the bases of the lungs are becoming œdematous, so that the patient is quite unfit for any exercise whatever. In such cases the best plan of treatment is to keep the patient absolutely quiet, and to allow of no exertion whatever. Now absolute quiet is a term which the patient is very likely to misunderstand. He will ask, "May I get up on the sofa? may I not get up for the wants of nature?" But the answer to this question must be "No, on no account whatever. You must remain absolutely quiet in bed; every voluntary movement that you make tends your heart to beat more quickly, and it is at such a low ebb that you must save it every beat you can." But if one keeps the patient so absolutely quiet with a feeble failing heart there is a natural tendency to stagnation in the extremities. This must be prevented by massage. The hand of the masseur or masseuse acts as an accessory heart, pressing the blood up and onwards to the heart, and by thus making room in the capillaries it lessens the resistance to the outward flow in the arteries. But more than this. By compression of the muscles the arterial flow is gradually increased, so that by massage we aid the feeble heart in a double way. We lessen the resistance it has to overcome by dilating the capillaries, and we help the circulation by pressing the blood onwards into the veins. Nor is this all. We also press on the lymph from the tissues. We thus maintain a proper tissue-metabolism, we increase the appetite, and eliminate waste. In this way we find that many cases, whom at first sight we might regard as practically moribund, recover in a way that is little short of marvellous, and perhaps there is no class of cases that so well repays the care and attention of the physician as those of bad cardiac disease.* But this subject I have already treated elsewhere, and my intention to-day has rather been to bring before you the good effect of exercise in preserving or restoring health, in giving a feeling of well-being and enjoyment of life, increasing strength and the power of resistance to disease, and of helping the development, both physical and mental, of the young. I have tried also to bring before you the bad effects of over-exercise in tending directly or indirectly to bring about disease, to destroy the enjoyment of life more or less permanently, and to diminish the power of work. More especially would I desire you to remember that mental exercise may produce physical exhaustion, and that to press either a growing boy or girl at the same time with hard mental work in the form of examinations, and with too much physical exercise,

* Lauder Brunton, "Rest and Massage in Cardiac Disease," *Practitioner*, vol. xli, No. 3.

even though it should be in the form of play, is a great mistake.

Years ago I thought it was impossible to have too much of a good thing, and in the self-sufficiency of youth I was inclined to regard Solomon as somewhat foolish when he said, "Be not righteous overmuch, neither make thyself over-wise, why shouldst thou destroy thyself?" The advance of years has taught me better, and I now acknowledge the wisdom of Solomon, and venture to apply his dictum to the body as well as the mind, and advise my medical brethren, as well as those who have the charge of youth, to take care that they shall neither try to make those who are under their care over-wise or over-strong, either by undue exertion of mind, of body, or of both.

Harrison & Sons, Printers in Ordinary to His late Majesty, St. Martin's Lane.



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